EXPERT REPORT OF JOWEI CHEN, Ph.D.

June 1, 2018

I am an Associate Professor in the Department of Political Science at the University of Michigan, Ann Arbor. I am also a Faculty Associate at the Center for Political Studies of the Institute for Social Research at the University of Michigan as well as a Research Associate at the Spatial Social Science Laboratory at Stanford University. In 2007, I received a M.S. in Statistics from Stanford University, and in 2009, I received a Ph.D. in political science from Stanford University. I have published academic papers on legislative districting and political geography in several political science journals, including *The American Journal of Political Science* and *The American Political Science Review*, and *Election Law Journal*. My academic areas of expertise include legislative elections, spatial statistics, geographic information systems (GIS) data, redistricting, racial politics, legislatures, and political geography. I have unique expertise in the use of computer simulations of legislative districting and to study questions related to political geography and redistricting.

I have provided expert reports in the following redistricting court cases: Missouri National Association for the Advancement of Colored People v. Ferguson-Florissant School District and St. Louis County Board of Election Commissioners (E.D. Mo. 2014); Rene Romo et al. v. Ken Detzner et al. (Fla. 2d Judicial Cir. Leon Cnty. 2013); The League of Women Voters of Florida et al. v. Ken Detzner et al. (Fla. 2d Judicial Cir. Leon Cnty. 2012); Raleigh Wake Citizens Association et al. v. Wake County Board of Elections (E.D.N.C. 2015); Corrine Brown et al. v. Ken Detzner et al. (N.D. Fla. 2015); City of Greensboro et al. v. Guilford County Board of Elections, (M.D.N.C. 2015); Common Cause et al. v. Robert A. Rucho et al. (M.D.N.C. 2016); League of Women Voters of Pennsylvania et al. v. Commonwealth of Pennsylvania et al. (No. 261 M.D. 2017); Georgia State Conference of the NAACP et al v. The State of Georgia et al. (N.D. Ga. 2017). I have testified at trial in the following cases: Raleigh Wake Citizens Association et al. v. Wake County Board of Elections (E.D.N.C. 2015); City of Greensboro et al. v. Guilford County Board of Elections (M.D.N.C. 2015); Common Cause et al. v. Robert A. Rucho et al. (M.D.N.C. 2016); League of Women Voters of Pennsylvania et al. v. Commonwealth of Pennsylvania et al. (No. 261 M.D. 2017). I am being compensated $500 per hour for my work in this case.

Research Questions and Summary of Findings:

The attorneys for the Plaintiffs in this case have asked me to analyze Michigan's current House, Senate, and Congressional districting plans, as created by Public Act 128 of 2011 and Public Act 129 of 2011. Specifically, I was asked to analyze whether each of these three enacted districting plans has the effect of producing an extreme partisan outcome that diverges from possible alternative maps.[1]

In conducting my academic research on legislative districting, partisan and racial gerrymandering, and electoral bias, I have developed various computer simulation programming techniques that allow me to produce a large number of non-partisan districting plans that adhere to traditional districting criteria using US Census geographies as building blocks. This simulation process is non-partisan in the sense that the computer ignores all partisan and racial considerations when drawing districts. Instead, the computer simulations are programmed to optimize districts with respect to various traditional districting goals, such as equalizing population, maximizing geographic compactness, and preserving county, municipal, and ward boundaries. By generating a large number of randomly drawn districting plans that closely follow and optimize on these traditional districting criteria, I am able to assess any enacted plan drawn by a state legislature and determine whether the enacted plan produces a partisan outcome that deviates from computer-simulated plans that follow traditional, partisan-neutral districting criteria.

More specifically, by holding constant the application of non-partisan, traditional districting criteria through the simulations, I am able to determine whether the enacted plans were partisan outliers.

I used this simulation approach to analyze Michigan's enacted House, Senate, and Congressional districting plans in several ways. First, I conducted 3,000 independent simulations, instructing the computer to generate 1,000 House, 1,000 Senate, and 1,000 Congressional districting plans for Michigan that strictly follow the non-partisan districting outlined in Act 463 of 1996 and Act 221 of 1999 and are reasonably geographically compact. I found that all 1,000 computer-simulated plans contain fewer county breaks and fewer municipal

[1] I reviewed Michigan's statutory redistricting guidelines in MCL § 3.63 et seq and MCL § 4.261 et seq and applied the criteria mandated in these statutes to produce a set of alternative maps for Michigan's Congressional, Senate, and House districting plans.

breaks than are contained in Michigan's enacted plan. The enacted plans' districts are also significantly more geographically non-compact than every single one of the 1,000 computer-simulated districting plans created for Michigan's House, Senate, and Congressional delegation.

Most importantly, I found that each of the enacted plans was a partisan outlier when compared to the computer-simulated plans. Each of the three enacted plans creates more Republican districts than every single one of the 1,000 computer-simulated districting plans created for Michigan's House, Senate, and Congressional delegation. Using common quantitative measures of political bias, including the Efficiency Gap and the Median-Mean Difference, every one of the computer-simulated plans is more politically neutral than Michigan's enacted Congressional, Senate, and House plans.

Michigan's Statutory Redistricting Guidelines And the Computer-Simulated Districting Algorithm

Michigan has two redistricting statutes - MCL § 4.261 et seq (Act 463 of 1996) and MCL § 3.63 et seq (Act 221 of 1999) – that describe in detail the criteria to be followed in the drawing of the state's Congressional, Senate, and House districts. The statutes describe five criteria to be followed in producing each districting plan: 1) Contiguity; 2) Equal population thresholds; 3) Minimizing county breaks; 4) Minimizing municipal breaks; and (as to some districts) 5) Geographic compactness. These five criteria are also traditional districting principles in the drawing of Congressional and state legislative districting plans.

Furthermore, both statutes state that the list of districting guidelines detailed in each statute is exhaustive. MCL § 4.261 mandates that House and Senate plans "shall be enacted using only the following guidelines," while MCL § 3.63 similarly requires that the drawing of congressional plans must follow "only these guidelines in the following order of priority." Hence, it is clear that both statutes not only specify the five districting criteria and their order of priority, but they also prohibit any other considerations, such as the partisan composition of districts or the protection of incumbents.

Appendix A of this report describes the details of the computer-simulated districting algorithm and how these five redistricting criteria are implemented by the computer algorithm in producing Congressional, Senate, and House plans.

districts that overlap with at least 50% of the total population of the enacted district. Using this method, I identify the following districts as partisan outliers:

In the enacted Congressional plan, Congressional Districts 1, 4, 5, 8, 9, 10, 11, and 12 are partisan outliers when compared to their respective computer-simulated geographically overlapping districts.

In the enacted Senate plan, Senate Districts 8, 9, 18, 22, 24, 27, and 32 are partisan outliers when compared to their respective computer-simulated geographically overlapping districts.

In the enacted House plan, House Districts 11, 12, 14, 16, 19, 20, 21, 30, 31, 32, 36, 43, 44, 45, 51, 52, 53, 55, 57, 60, 62, 63, 65, 69, 75, 76, 80, 87, 91, 92, 94, 98, 103, 105, 106, and 107 are partisan outliers when compared to their respective computer-simulated geographically overlapping districts.

Absent some other explanation, this analysis strongly suggests that these outlier districts listed above are the most effectively cracked and packed districts in the enacted maps. In addition, when an enacted district has zero computer-simulated districts that overlap with 50% of enacted district's population, such a finding indicates that the enacted district was drawn in a manner that did not follow Michigan's statutory redistricting guidelines.

Appendix A:
Michigan's Statutory Redistricting Guidelines
And the Computer-Simulated Districting Algorithm

Michigan has two redistricting statutes - MCL § 4.261 et seq (Act 463 of 1996) and MCL § 3.63 et seq (Act 221 of 1999) – that describe in detail the criteria to be followed in the drawing of the state's Congressional, Senate, and House districts. The statutes describe five criteria to be followed in producing each districting plan: 1) Contiguity; 2) Equal population thresholds; 3) Minimizing county breaks; 4) Minimizing municipal breaks; and 5) Geographic compactness. Furthermore, the statutes even establish a hierarchy specifying which criteria are to be prioritized over others when drawing districts: Both statutes are clear that district contiguity is an absolutely inviolable principle and that county and municipal lines may be broken only for the purpose of satisfying the district population threshold requirements. This statutory hierarchy thus establishes a clear order of priority for the five districting criteria. For example, a districting plan may not create additional county or municipal breaks for the sake of improving district compactness; nor may a plan deviate from the district population thresholds for the sake of avoiding a county or municipal break.

Furthermore, both statutes state that the list of districting guidelines detailed in each statute is exhaustive. MCL § 4.261 mandates that House and Senate plans "shall be enacted using only the following guidelines," while MCL § 3.63 similarly requires that the drawing of Congressional plans must follow "only these guidelines in the following order of priority." Hence, it is clear that both statutes not only specify the five districting criteria and their order of priority, but they also prohibit any other considerations, such as the partisan composition of districts or the protection of incumbents.

Because of the clarity, specificity, and exhaustiveness of MCL § 4.261 and MCL § 3.63 regarding the five districting criteria, as well as their order of priority, programming the districting simulation algorithm to produce Congressional, Senate, and House plans for Michigan was a purely technical exercise, with no subjective judgment or guesswork needed. I simply followed the criteria detailed by the two redistricting statutes and instructed the computer algorithm to adhere strictly to these criteria, with no other considerations permitted.

The simulation algorithm proceeds as follows: First, the algorithm begins with a set of base geographies to be used as building blocks for constructing a simulated plan. In creating State House plans, I use Voting Tabulation District (VTD) boundaries as the building blocks. In

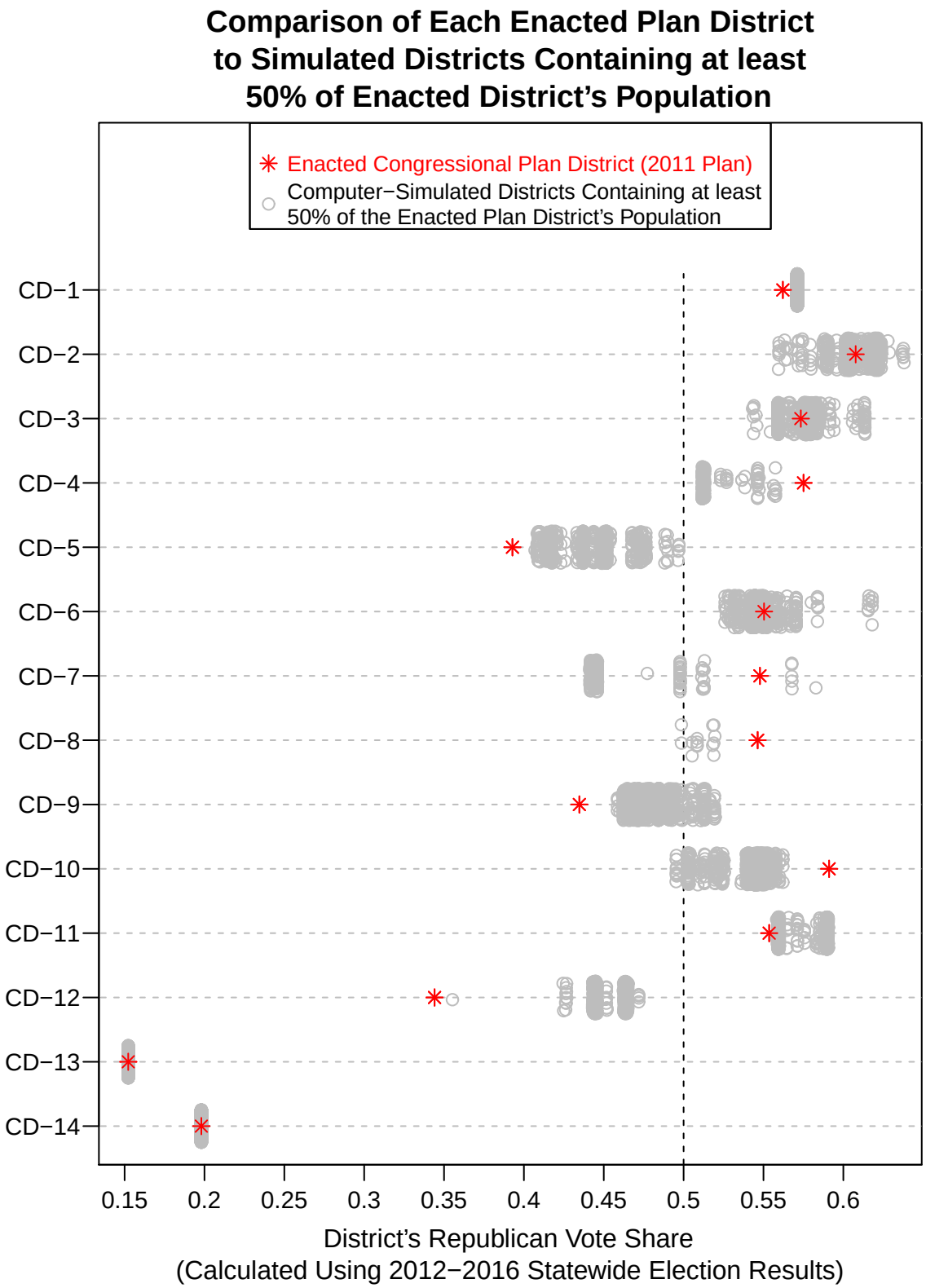
creating State Senate and Congressional plans, I use municipal (MCD) boundaries as the building blocks for simulated plans. Second, the algorithm randomly divides up these geographies into the appropriate number of contiguous districts (eg, 38 State Senate districts), each of roughly equal population; at this point, these districts are unlikely to be of perfectly equal population. Third, the algorithm then considers each of 10 million randomly-proposed, iterative changes to the various boundaries between the districts. Each of these proposed iterative changes is randomly generated, with no partisan or racial considerations considered. Each proposed iterative change is accepted only if the resulting districts 1) Would be within the 5% population deviation threshold statutorily mandated for Senate and House districting plans; 2) Would not increase the number of county breaks across the entire plan; and 3) Would not increase the number of municipal breaks across the entire plan. By considering and selectively implementing a large number of random iterative changes to the districts' boundaries, the algorithm thus gradually decreases the number of county and municipal breaks in the plan. These iterative changes result in a plan in which county and municipal breaks occur only when absolutely necessary to comply with the equal population and contiguity mandates of Michigan's redistricting guidelines.

In simulating Congressional plans, the algorithm contains one additional step not used when simulating Senate and House plans: Unlike State House and Senate districts, Congressional districts are required to contain perfectly equal populations. Thus, after the aforementioned steps, the algorithm randomly selects municipalities to be broken only when necessary for equalizing the populations of all Congressional districts. The algorithm considers a large number of possible breaks of the municipality, and the possible break that maximizes district compactness is selected. This final step results in Congressional districts that contain a population of either 705,974 or 705,975, while otherwise minimizing county and municipal breaks and preserving district contiguity.

Below, I describe in detail these five districting criteria in order of priority and explain how each criterion is implemented by the computer algorithm in producing simulated plans for Michigan's Congressional, Senate, and House districts:

1) *District Contiguity:* Michigan statute requires Congressional, Senate, and House districts to be "contiguous by land," while specifying that contiguity cannot be achieved through "areas that meet only at points of adjoining corners" (MCL 3.63(i) and MCL 4.261(c)).

Appendix D3:


Comparison of Each Enacted Plan District to Simulated Districts Containing at least 50% of Enacted District's Population
Enacted Congressional Plan District (2011 Plan)
Computer−Simulated Districts Containing at least 50% of the Enacted Plan District's Population
CD−1
CD−2
CD−3
CD−4
CD−5
CD−6
CD−7
CD−8
CD−9
CD−10
CD−11
CD−12
CD−13
CD−14
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
District's Republican Vote Share
(Calculated Using 2012−2016 Statewide Election Results)